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THE ORTHO-PARA H_2 DISTRIBUTION ON URANUS: CONSTRAINTS FROM THE COLLISION-INDUCED 3-0 DIPOLE BAND AND 4-0 S(0) AND S(1) QUADRUPOLE LINE PROFILES

K. H. Baines and J. T. Bergstralh
Jet Propulsion Laboratory, California Institute of Technology

The presentation by Baines and Bergstralh is largely contained in a paper which appears in the special issue of Icarus (1986; 65, 406-441). The abstract of the conference presentation is reproduced here.

S(0) and S(1) absorptions by H_2 are prominent in Uranus' spectrum, both as broad (≈60 Å) collision-induced dipole features and narrow (≈0.08 Å) quadrupole lines. The 3-0 and 4-0 bands near 6400 and 8200 Å are useful for deriving atmospheric properties since they are much stronger than higher overtones and occur in regions of relatively weak CH_4 absorptions. Three features seem to be particularly free of CH_4 extinction effects: the 3-0 S(1) collision-induced feature at 8260 Å, and the profiles of the 4-0 S(0) and S(1) quadrupole lines at 6435 and 6369 Å. Current analysis suggests that the distribution of ortho-para H_2 departs significantly from equilibrium on a global scale, with perhaps as much as 60% of the gas being distributed "normally." The interpretation of these data, however, depends strongly on three controversial issues: the line strengths and time constants for the 4-0 quadrupole and 3-0 dipole features, the dependence of the background methane absorption on temperature, and the nature of the aerosol distribution in the Uranian atmosphere. The latter two issues are discussed in particular, drawing upon our experience in modeling other portions of the existing Uranian spectral data set. Our current analysis indicates that an ortho/para distribution wherein approximately 75% of the gas is in the equilibrium state is most consistent with theoretical 4-0 quadrupole line strengths.

DR. BELTON: Could you just go over that hand-drawn representation of the methane band data?

DR. BAINES: Perhaps Bill Smith should describe it. It's his data. My main point was to emphasize the change in character of the 6190 Å band as a function of temperature.

DR. W. H. SMITH: We recently obtained data on the absorption in the region of the 6190 Å methane band using the photoacoustic technique. At present this is all raw data, and it has not been normalized. So there is a baseline slope which is dependent on the detailed conditions of the measurement. At room temperature you get a nice symmetric band shape for the 6190 Å feature after you remove the baseline slope. But when you make the measurement at cold temperatures, the band changes shape. There are apparently two bands in this region. At the cold temperatures, you lose a lot of absorption on the blue side of the feature, whereas on the red side, it doesn't change very much.

DR. LUTZ: What was the resolution for the spectrum you showed of Uranus?

DR. BAINES: It was 10 Å resolution.

DR. LUTZ: I tried to get a feeling for scale and ask you about this before. The laboratory spectrum is one angstrom resolution. Even at 10 Å, I'm surprised that in the Uranus spectrum you don't see the shoulder evident in the low-temperature lab spectrum.

DR. BAINES: We may be...

DR. LUTZ: Well, the spectrum you showed didn't show it...

DR. BAINES: Well, it's a very steep curve on the spectrum and it's very hard to see...

DR. LUTZ: But Uranus is a low-temperature "laboratory," isn't it?

DR. BAINES: Yes.

DR. LUTZ: So it should have had a low-temperature shape, shouldn't it have?

DR. BAINES: It may be in there, I don't know.

DR. CONRATH: At which levels are your observations most sensitive?

DR. BAINES: Basically what happens is that we are sampling different levels depending on what part of the line profile you look at. A point near the peak corresponds to about 100-200 millibars, whereas out in the wing it is more like two bars. The average line formation is one bar, but it depends on how you want to analyze this. Basically, it's a lot like the infrared where you sample different places in the atmosphere depending on where on the shoulder of a line you are. If you had really high resolution data, it could be used in that way to probe a number of levels in the atmosphere.

DR. MCKINNON: Why did you emphasize the theoretical line profile estimate of S(1)/S(0), as opposed to existing measurements?

DR. BAINES: Well, theoretical line profiles agree pretty well with the other quadrupole lines, 2-0, 3-0, 1-0. Most of the time they tend to agree. It's only in 4-0 that it seems like the few laboratory measurements have been in disagreement with the theoretical. Those laboratory measurements have been all over the place. The latest ones, at least for S(1), have been in agreement with theoretical. The controversy there is the S(0) measurement, and that's why the ratio, S(1)/S(0) is so different. It's the S(0) line, and there has only been one of those measurements made, by Sue Bragg. There's some speculation that it may be a little off. There's only this one real laboratory measurement of S(0).

DR. PODOLAK: Could you just say something about where the aerosols fit in the model.

DR. BAINES: That's constrained by the other parts of the broadband spectrum. Basically, it's wavelength dependent. In this case, the optical depth can go from zero to about 0.75 or so to limits...

DR. PODOLAK: Optical depth? What kind of depth do you have here?

DR. BAINES: Depending on the models you use, basically starting around 700 mb and going anywhere up to--it could be as high as 200 mb, but normal models stop around 400 mb.

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